

**American College of Radiology
ACR Appropriateness Criteria®**

Clinical Condition: Suspected Upper-Extremity Deep Vein Thrombosis

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
US upper extremity(ies) with Doppler	9	Standard for arm veins. Other modalities required for evaluating central veins.	O
X-ray chest	8	Simple, low cost evaluation of lines, mediastinal contours, and cervical ribs.	☼
MRA chest (noncoronary) without and with contrast	7	Asymptomatic side injection preferred. For central veins. See statement regarding contrast in text under “Anticipated Exceptions.”	O
Venography upper extremity(ies) and SVC	7	Although the gold standard, generally reserved for inconclusive noninvasive studies.	☼ ☼ ☼
CTA chest (noncoronary)	7	Asymptomatic side injection preferred. Alternative to MRA for central veins.	☼ ☼ ☼
Radionuclide venography upper extremity(ies) and chest	3	Largely supplanted. Limited use for central veins when CTA and MRA are both contraindicated.	☼ ☼ ☼
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

SUSPECTED UPPER-EXTREMITY DEEP VEIN THROMBOSIS

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Summary of Literature Review

Introduction/Background

Upper-extremity venous thrombosis often presents as unilateral arm swelling. The differential diagnosis includes a mass lesion or other lesion compressing the veins and causing a functional venous obstruction, venous stenosis, or an infection causing edema [1]. Bilateral upper-extremity swelling may also be due to right-sided heart failure, although this is typically associated with generalized swelling, in contrast to central vein obstruction, which can cause swelling limited to the upper extremity and face [1].

Obstruction of previously functioning lymphatics or the absence of sufficient lymphatic channels to ensure effective drainage may also cause arm swelling. Lymphatic obstruction can be seen with infection such as cellulitis or can be secondary to invasion of the lymphatics by tumor. Absence of the lymphatics can be congenital or secondary to surgery, such as following a radical mastectomy [2].

The following recommendations are made with the understanding that venous disease, specifically venous thrombosis, is the primary diagnosis to be excluded or confirmed in a patient presenting with unilateral upper-extremity swelling.

Upper-Extremity Deep Vein Thrombosis

Upper-extremity deep vein thrombosis (DVT) can be associated with indwelling catheters [3-7], be idiopathic or posttraumatic [5,8], or be secondary to extrinsic compression syndrome ("effort thrombosis" or Paget-Schrötter disease) [5,9].

Upper-extremity DVT is commonly associated with the presence of indwelling central venous catheters [3,6,7,10-12]. The presence of the catheter, a foreign body,

increases the likelihood of venous thrombosis by altering flow [1], causing damage to the endothelial lining of the vein, and serving as a site for platelet adherence [1]. The increased use of chronically indwelling catheters for hemodialysis, chemotherapy, or parenteral nutrition, often in a population that already has additional risk factors for venous thrombosis, has increased the incidence of upper-extremity DVT. As is the case with lower-extremity DVT, the likelihood of upper-extremity DVT increases with the presence of risk factors such as age, previous thrombophlebitis, postoperative state, hypercoagulability [3,4,8], heart failure [3], cancer [4-8,11,13], right heart procedures, and ICU admissions [7].

The location of the venous thrombosis is strongly linked to the clinical presentation. For example, head, neck, and bilateral upper-extremity swelling suggest a central process in the mediastinum [1] involving the superior vena cava or both subclavian and brachiocephalic systems [14]. Superficial thrombophlebitis is associated with local pain, induration, and, often, a palpable cord. It is rarely, if ever, associated with diffuse arm swelling [15]. Unilateral swelling indicates an obstructive process at the level of the brachiocephalic, subclavian, or axillary veins [14,15]. DVT limited to the brachial veins need not be associated with swelling. Isolated jugular vein thrombosis is asymptomatic and rarely causes swelling. There may be a correlation between upper-extremity and lower-extremity DVT, and investigation of the lower extremities as well should be considered if an upper-extremity thrombus is found in the absence of a local cause [16].

Differentiating Causes of Upper-Extremity Swelling

The initial approach to a patient who presents with a swollen upper extremity is exclusion of venous thrombosis because anticoagulation is typically required and the underlying lesion may require a more aggressive intervention such as thrombolysis. Once the diagnosis of DVT is excluded, other etiologies may need to be evaluated. Different imaging techniques that can be used to achieve the diagnosis include noninvasive tests such as radionuclide venography, ultrasound (US), magnetic resonance imaging (MRI), computed tomography (CT), and finally venography.

Chest Radiography

Because of the broad differential diagnoses of upper-extremity swelling, a chest radiograph may identify a mass lesion responsible for central venous obstruction or help confirm the presence and location of wires, catheters, or a retained wire or catheter fragment. Rare osseous entities that might be associated with extrinsic compression syndromes, such as a cervical rib, would also be detected.

Radionuclide Imaging, Flow Studies

Radionuclide studies can confirm upper-extremity venous obstruction. The diagnostic criteria include failure to visualize one or more of the main venous segments

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(axillary, subclavian, brachiocephalic, or superior vena cava) and visualization of collateral venous channels. This test is typically not able to differentiate intrinsic venous thrombosis from extrinsic compression [2,17-19].

X-ray Venography

This is the “reference standard” [20] examination for evaluating the upper-extremity veins. The examination carries the risks associated with the injection of an iodinated contrast agent [20,21]. Patient tolerance has been improved, and the risks of adverse events have been reduced with low-osmolar contrast agents. Direct evidence of venous thrombus is based on the visualization of a filling defect in the vein or of an abrupt occlusion, usually with the presence of collateral channels [22]. Venography can identify fixed venous stenoses and, with upper-extremity maneuvers (abduction), can identify extrinsic venous compression. Asymptomatic or minimally symptomatic venous compression with arm abduction should be treated with caution, as this finding can be made in a substantial number of normal individuals. Despite its widespread acceptance as a reference standard based on extension of evidence associated with lower-extremity DVT, there are limited clinical trials supporting its use.

Venous Ultrasound

This relatively inexpensive test can exclude DVT and help identify a proximal venous obstruction. Diagnostic criteria for direct evidence of thrombus, as in the lower extremity, include loss of compressibility and visualization of echogenic material in the vein, whereas indirect evidence includes altered blood flow patterns [8,21-25]. Compressibility of the vein is evaluated by applying pressure to the soft tissues overlying the vein. Loss of compressibility is consistent with acute DVT but can also occur in the presence of chronic venous thrombosis [8,22]. This can be used for peripheral veins such as jugular, axillary, basilic, cephalic, and brachial veins. Compression cannot be used to evaluate subclavian or more central veins, as bony structures prevent visualization and/or compression of the veins.

A full examination also includes evaluation of the Doppler velocity profiles obtained from blood in the major veins. Reduction in Doppler velocity changes due to cardiac pulsatility are reliable indicators of central venous obstruction [12,25,26]. In addition, respiratory maneuvers such as rapid inspiration or “sniffing” should cause the walls of the subclavian veins to collapse [20,26,27]. Impairment of this collapse (which is related to rapid venous emptying) also indicates a central obstructive process [10,25,26]. However, a central thrombus will cause the same alterations in blood flow as a mass encasing or compressing the central (superior vena cava, brachiocephalic) veins or a benign stricture. Color flow imaging can be used to image the presence or absence of flow within the vein and is useful in evaluating venous segments where compression maneuvers cannot be applied [8,10,26] (eg, central subclavian vein), although a study has suggested that if *only* blood flow

abnormalities are seen, conventional venography may be necessary [8].

Gray-scale imaging can be used to identify echogenic thrombus. However, acute hypoechoic thrombi may be missed using gray-scale imaging alone. Adjunctive use of color flow images can help in confirming the presence or absence of hypoechoic thrombus. Correlative studies between ultrasound and venography show diagnostic sensitivities and specificities above 80% [5,8,10,12,20-22,25,27-29].

Magnetic Resonance Imaging

Approaches to venous imaging using MRI include black-blood and flow-based or contrast-enhanced bright-blood techniques [30]. *Black-blood* techniques include conventional T1 or T2 spin-echo [24,31] or fast spin-echo imaging. However, the black blood effect on routine spin-echo imaging may not be consistent, and newer double inversion-recovery techniques provide more reliable black blood imaging [30]. Using black-blood imaging, the presence of thrombus is inferred from focal high signal, often with enlargement, of the involved vein, but it must be differentiated from a variety of flow artifacts [31].

Flow-based bright-blood MR venography (MRV) techniques include time-of-flight (TOF) [30,32,33] and phase contrast [30,31]. For venous imaging, TOF is limited to a 2D implementation due to signal saturation of slow flow [34]. Vessels with primarily in-plane flow are more difficult to image due to saturation [34]; 2D TOF is thus most useful in the axial plane to image flow in the jugular veins, right brachiocephalic vein, and superior vena cava (SVC) which are oriented primarily in the superior-inferior direction. TOF venography can be used to image the subclavian vein, but more time-consuming sagittal acquisitions are preferred due to the direction of flow, and breathing artifacts may also impair imaging quality [4,34]. Phase contrast has not been widely used for upper-extremity venography due to the slow flows that must be detected [34]. Recently, balanced gradient echo (steady-state free precession), and cardiac-gated 3D fast spin-echo techniques have been implemented for noncontrast MR vessel imaging. While these techniques have not been evaluated for chest venography, they appear promising [34-36].

Contrast-enhanced MRV [32,37,38] can also be used by implementing 2D or 3D T1 gradient echo images with fat saturation after administration of a single or a double dose of MR contrast [34]. Typically, venous imaging is carried out after an MR arteriogram by simply imaging out into the venous or equilibrium phases of contrast distribution [30,34]; new time-resolved imaging allows visualization of flow dynamics and may decrease required contrast volume and acquisition time [39]. It has found use in protocols for whole-body venography [40].

The advantages of MRV are primarily for central venous evaluation, as the central veins cannot be imaged directly by US. For imaging the arm itself, US or even x-ray venography is preferred. MRV of the arm is rendered more difficult by its placement at the periphery of the

magnetic field or the requirement to maintain the arm motionless over the head. Studies so far specifically comparing MRV to venography have been mixed, with some work showing MRV to be as effective as venography [33,38], but other work showing its limitations [24,31,32].

Computed Tomography

CT can be used to determine the presence of centrally located thrombi or stenoses within the jugular veins [41,42], the brachiocephalic veins [43,44], and the superior vena cava [43]. The presence of an extrinsic process causing venous obstruction of the venous channels can also be determined [45]. Delayed imaging at 90 to 120 seconds can permit evaluation of the central veins. It is important to administer large doses of contrast (up to 150 cc) in order to ensure adequate venous opacification. New techniques involving dual injections of contrast have been developed for CT venography and look promising [46]. No large series have looked at the diagnostic accuracy of this technique for diagnosing upper-extremity venous thrombosis, although extensive experience is accumulating with lower-extremity venous thrombosis. One small series does show CT venography to perform similarly to conventional venography in the thoracic and upper-extremity veins, as well as to evaluate the central extent of obstruction more effectively [45].

Summary

- Despite the availability of noninvasive imaging techniques, contrast venography remains the best reference standard diagnostic test for suspected upper-extremity acute venous thrombosis.
- Contrast venography may be needed whenever other noninvasive strategies fail to adequately image the upper-extremity veins. Additionally, as venography is the first step in direct catheter-based thrombolysis, in situations such as acute upper-extremity DVT where the likelihood of percutaneous thrombectomy or thrombolysis is high, it is sensible to proceed directly to venography.
- Duplex, color flow, and compression ultrasound have also established a clear role in evaluation of the more peripheral veins that are accessible to sonography.
- Imaging with gadolinium contrast-enhanced MRI is routinely used to evaluate the status of the central veins. Unfortunately, despite widespread clinical use, there are few validation studies compared to the literature on contrast venography. The recognition of gadolinium as a cause of nephrogenic systemic fibrosis has increased interest in noncontrast MR venography, but validation of these techniques in the chest remains an issue.
- Delayed computed tomographic venography can often be used to confirm or exclude more central vein venous thrombi, although substantial contrast loads are required. As in the case of MR venography, there are few correlative studies justifying this approach.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, $<30 \text{ mL/min/1.73m}^2$), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates $<30 \text{ mL/min/1.73m}^2$. For more information, please see the [ACR Manual on Contrast Media](#) [47].

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☼	<0.1 mSv	<0.03 mSv
☼☼	0.1-1 mSv	0.03-0.3 mSv
☼☼☼	1-10 mSv	0.3-3 mSv
☼☼☼☼	10-30 mSv	3-10 mSv
☼☼☼☼☼	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as NS (not specified).		

Supporting Document(s)

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Contrast Information](#)
- [Evidence Table](#)

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.